What is Claimed is:

1. A computer-implemented method for combining at least two over-
lapping layers to render an image, the image containing a plurality of image
pixels, each overlapping layer containing a plurality of layer pixels, each layer
pixel corresponding to one of the image pixels, the method comprising:

    a')   defining a tile, the tile comprising a subset of the image pixels
            delimited according to an area of overlap among a set of at least
            two layers, so that a first portion of the image lies within the tile
            and a second portion of the image lies outside the tile; and

    a)   processing the first portion of the image distinctly from the second
            portion of the image by, for at least one image pixel in the defined
            tile:

            a.1)   initializing an accumulator color value;

            a.2)   selecting one of the layers in the set of at least two layers, the
                    selected layer having a layer pixel corresponding to the
                    image pixel, the layer pixel having a color value;

            a.3)   compositing the color value of the layer pixel with the
                    accumulator color value;

            a.4)   storing the result of a.3) in the accumulator;

19   a.5)   determining whether layer pixels for any remaining layers in

20   the set of at least two layers should be processed;

21   a.6)   responsive to a.5) indicating that layer pixels for any

22   remaining layers should be processed, repeating a.2) to a.6);

23   and

24   a.7)   outputting the accumulator color value.

1   2. The method of claim 1, wherein each layer pixel has an opacity value,

2   and wherein:

3   a.1) further comprises initializing an accumulator opacity value;

4   a.3) further comprises compositing the opacity value of the layer pixel

5   with the accumulator opacity value; and

6   a.5) comprises determining whether the accumulator opacity value

7   indicates full opacity.

1   3. The method of claim 1, wherein a.2) comprises selecting a topmost

2   remaining layer in the set of at least two layers.

1   4. The method of claim 1, wherein a.7) comprises outputting the ac-

2   cumulator value to a frame buffer.

1   5. The method of claim 1, further comprising

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2 b) displaying the image.

1 6. The method of claim 1, further comprising:

2 b) repeating a) for each image pixel in the defined tile.

1 7. The method of claim 1, wherein a) comprises performing a.1) through

2 a.7) for at least two image pixels concurrently.

1 8. The method of claim 1, further comprising:

2 b) concurrently with a), for a second image pixel in the defined tile:

3   b.1) initializing a second accumulator color value;

4   b.2) selecting one of the layers in the set of at least two layers, the

5   selected layer having a second layer pixel corresponding to

6   the second image pixel, the second layer pixel having a color

7   value;

8   b.3) compositing the color value of the second layer pixel with

9   the second accumulator color value;

10   b.4) storing the result of b.3) in the second accumulator;

11   b.5) determining whether layer pixels for any remaining layers in

12   the set of at least two layers should be processed;

13   b.6)   responsive to b.5) indicating that layer pixels for any

14   remaining layers should be processed, repeating b.2) to b.6);

15   and

16   b.7)   outputting the second accumulator color value.

1   9. The method of claim 1, wherein at least one of the layers in the set of at

2   least two layers is non-rectangular.

1   10. The method of claim 1, wherein at least one pixel of at least one of the

2   layers in the set of at least two layers is transparent, and wherein a.3) comprises:

3   a.3.1) responsive to the layer pixel being transparent, retaining the

4   accumulator color value; and

5   a.3.2) responsive to the layer pixel not being transparent, compositing the

6   color value of the layer pixel with the accumulator color value.

1   11. The method of claim 1, further comprising:

2   b') repeating a') and a) for at least one second defined tile.

1   12. The method of claim 1, wherein each layer comprises a window, and

2   wherein the image comprises a display for a windowing system.

1   13. The method of claim 1, wherein a first one of the layers in the set

2   overlaps a second one of the layers in the set, and wherein each layer comprises

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3   bounds defined by edges, and wherein at least one edge of the first layer lies

4   within the bounds of the second layer, and wherein a') comprises:

5   subdividing the second layer along a line corresponding to an extension of

6   the at least one edge of the first layer that lies within the bounds of

7   the second layer.

1   14. The method of claim 1, wherein:

2   a.2) comprises selecting one of the layers in the set of at least two layers,

3   the selected layer having a layer pixel corresponding to the image

4   pixel, the layer pixel having a color value and an alpha value; and

5   a.3) comprises compositing the color value of the layer pixel with the

6   accumulator color value, using the alpha value.

1   15. A system for combining at least two overlapping layers to render an

2   image, the image containing a plurality of image pixels, each overlapping layer

3   containing a plurality of layer pixels, each layer pixel corresponding to one of the

4   image pixels, the system comprising:

5   a tile subdivider, for defining a tile, the tile comprising a subset of the

6   image pixels delimited according to an area of overlap among a set

7   of at least two layers, so that a first portion of the image lies within

8   the tile and a second portion of the image lies outside the tile;

9   an accumulator, for initializing an accumulator color value for at least one

10   image pixel in the defined tile;

11   a layer selector, coupled to the tile subdivider, for successively selecting

12   each of at least a subset of the layers in the set of at least two layers,

13   each selected layer having a layer pixel corresponding to the image

14   pixel, the layer pixel having a color value;

15   a compositor coupled to the layer selector and to the accumulator, for, for

16   each successively selected layer, compositing the color value of the

17   layer pixel with the accumulator color value and storing the result

18   in the accumulator; and

19   an output device, coupled to the accumulator, for outputting the ac-

20   cumulator color value;

21   wherein in combining the overlapping layers, the accumulator, the layer

22   selector, and the compositor process the first portion of the image

23   distinctly from the second portion of the image.

1   16. The system of claim 15, wherein each layer pixel has an opacity value,

2   and wherein:

3   the accumulator further initializes an accumulator opacity value;

4   the compositor further composites the opacity value of the layer pixel

5   with the accumulator opacity value and stores the result in the

6   accumulator; and

7   the subset of overlapping layers selected by the layer selector is deter-

8   mined responsive to a comparison of the accumulator opacity

9   value with a full opacity value.

1   17. The system of claim 15, wherein the layer selector successively selects

2   layers by selecting a topmost remaining layer in the set of at least two layers.

1   18. The system of claim 15, wherein the output device outputs the ac-

2   cumulator value to a frame buffer.

1   19. The system of claim 15, further comprising a display device, coupled

2   to the output device, for displaying the image.

1   20. The system of claim 15, wherein each of the layer selector, compositor,

2   accumulator, and output device operates on each image pixel in the defined tile.

1   21. The system of claim 15, wherein the layer selector, compositor, ac-

2   cumulator, and output device each operate on at least two image pixels con-

3   currently.

1   22. The system of claim 15, further comprising a second accumulator,

2   coupled to the compositor, wherein:

3   the second accumulator initializes a second accumulator color value for a

4   second image pixel in the defined tile;

5   the layer selector, concurrently with successively selecting each of at least

6   a subset of the layers in the set of at least two layers having a layer

7   pixel corresponding to the first image pixel, selects one of the layers

8   in the set of at least two layers having a second layer pixel

9   corresponding to the second image pixel, the second layer pixel

10   having a color value;

11   the compositor, concurrently with compositing the first color value of the

12   layer pixel with the accumulator color value, composites the color

13   value of the second layer pixel with the second accumulator color

14   value and stores the result in the second accumulator; and

15   the output device outputs the second accumulator color value.

1   23. The system of claim 15, wherein at least one of the layers in the set of

2   at least two layers is non-rectangular.

1   24. The system of claim 15, wherein at least one pixel of at least one of the

2   layers in the set of at least two layers is transparent, and wherein the compositor:

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3   responsive to the layer pixel being transparent, retains the accumulator

4   color value; and

5   responsive to the layer pixel not being transparent, composites the color

6   value of the layer pixel with the accumulator color value.

1   25. The system of claim 15, wherein:

2   the tile subdivider defines as a second tile a second area of overlap

3   between a second set of at least two layers, the tile comprising a

4   second subset of the image pixels;

5   the accumulator initializes a second accumulator color value for at least

6   one image pixel in the second defined tile;

7   the layer selector successively selects each of at least a subset of the layers

8   in the second set of at least two layers, each selected layer having a

9   layer pixel corresponding to the image pixel, the layer pixel having

10   a color value;

11   the compositor, for each successively selected layer, composites the color

12   value of the layer pixel with the second accumulator color value

13   and stores the result in the accumulator; and

14   the output device outputs the second accumulator color value.

1   26. The system of claim 15, wherein each layer comprises a window, and

2   wherein the image comprises a display for a windowing system.

1   27. The system of claim 15, wherein a first one of the layers in the set

2   overlaps a second one of the layers in the set, and wherein each layer comprises

3   bounds defined by edges, and wherein at least one edge of the first layer lies

4   within the bounds of the second layer, and wherein the tile subdivider

5   subdivides the second layer along a line corresponding to an extension of the at

6   least one edge of the first layer that lies within the bounds of the second layer.

1   28. The system of claim 15, wherein:

2   the layer selector successively selects each of at least a subset of the layers

3   in the set of at least two layers, each selected layer having a layer

4   pixel corresponding to the image pixel, the layer pixel having a

5   color value and an alpha value; and

6   the compositor composites the color value of the layer pixel with the

7   accumulator color value, using the alpha value.

1   29. A computer program product comprising a computer-usable medium

2   having computer-readable code embodied therein for combining at least two

3   overlapping layers to render an image, the image containing a plurality of image

4   pixels, each overlapping layer containing a plurality of layer pixels, each layer

5   pixel corresponding to one of the image pixels, the computer program product

6   comprising:

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7   computer-readable program code devices configured to cause a computer

8   to define a tile, the tile comprising a subset of the image pixels

9   delimited according to an area of overlap among a set of at least

10   two layers, so that a first portion of the image lies within the tile

11   and a second portion of the image lies outside the tile; and

12   computer-readable program code devices configured to cause a computer

13   to process the first portion of the image distinctly from the second

14   portion of the image by, for at least one image pixel in the defined

15   tile:

16   initializing an accumulator color value;

17   selecting one of the layers in the set of at least two layers, the

18   selected layer having a layer pixel corresponding to the

19   image pixel, the layer pixel having a color value;

20   compositing the color value of the layer pixel with the accumulator

21   color value;

22   storing the result of the compositing in the accumulator;

23   determining whether layer pixels for any remaining layers in the

24   set of at least two layers should be processed;

25   responsive to the determination indicating that layer pixels for any

26   remaining layers should be processed, repeating the

27   initializing, selecting, compositing, storing, and determining

28   steps; and

29   outputting the accumulator color value.

1   30. The computer program product of claim 29, wherein each layer pixel

2 has an opacity value, and wherein:

3   the computer-readable program code devices configured to cause a com-

4   puter to initialize further comprise computer-readable program

5   code devices configured to cause a computer to initialize an

6   accumulator opacity value;

7   the computer-readable program code devices configured to cause a com-

8   puter to composite further comprise computer-readable program

9   code devices configured to cause a computer to composite the

10   opacity value of the layer pixel with the accumulator opacity value;

11   and

12   the computer-readable program code devices configured to cause a com-

13   puter to determine whether layer pixels for any remaining layers

14   should be processed comprise computer-readable program code

15   devices configured to cause a computer to determine whether the

16   accumulator opacity value indicates full opacity.

1   31. The computer program product of claim 29, wherein the computer-

2   readable program code devices configured to cause a computer to select one of

3   the layers comprise computer-readable program code devices configured to

4   cause a computer to select a topmost remaining layer in the set of at least two

5   layers.

1   32. The computer program product of claim 29, wherein the computer-

2   readable program code devices configured to cause a computer to output the

3   accumulator color value comprise computer-readable program code devices

4   configured to cause a computer to output the accumulator value to a frame

5   buffer.

1   33. The computer program product of claim 29, further comprising:

2   computer-readable program code devices configured to cause a computer

3   to display the image.

1   34. The computer program product of claim 29, further comprising:

2   computer-readable program code devices configured to cause a computer

3   to repeat the initializing, selecting, compositing, storing,

4   determining, and outputting for each image pixel in the defined

5   tile.

1   35. The computer program product of claim 29, wherein the computer-

2 readable program code devices are configured to cause a computer to perform

3 the initializing, selecting, compositing, storing, and outputting for at least two

4 image pixels concurrently.

1   36. The computer program product of claim 29, further comprising:

2   computer-readable program code devices configured to cause a computer

3   to, for a second image pixel in the defined tile and concurrently

4   with the selecting, compositing, storing, and outputting for the first

5   image pixel:

6   initialize a second accumulator color value;

7   select one of the layers in the set of at least two layers, the selected

8   layer having a second layer pixel corresponding to the

9   second image pixel, the second layer pixel having a color

10   value;

11   composite the color value of the second layer pixel with the second

12   accumulator color value;

13   store the result of the compositing in the second accumulator;

14   determine whether layer pixels for any remaining layers in the set

15   of at least two layers should be processed;

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16   responsive to the determination indicating that layer pixels for any

17   remaining layers should be processed, repeat the initializing,

18   selecting, compositing, storing, and determining steps; and

19   output the second accumulator color value.

1   37. The computer program product of claim 29, wherein at least one of

2 the layers in the set of at least two layers is non-rectangular.

1   38. The computer program product of claim 29, wherein at least one pixel

2 of at least one of the layers in the set of at least two layers is transparent, and

3 wherein the computer-readable program code devices configured to cause a

4 computer to composite the color value of the layer pixel with the accumulator

5 color value comprise computer-readable program code devices configured to

6 cause a computer to:

7   responsive to the layer pixel being transparent, retain the accumulator

8   color value; and

9   responsive to the layer pixel not being transparent, composite the color

10   value of the layer pixel with the accumulator color value.

1   39. The computer program product of claim 29, further comprising:

2 computer-readable program code devices configured to cause a computer

3   to define as a second tile an area of overlap between a set of at least

4   two layers, the second tile comprising a second subset of the image

5   pixels; and

6   computer-readable program code devices configured to cause a computer

7 to repeat the initializing an accumulator color value, selecting one of the layers,

8 compositing, storing, repeating, and outputting, for the second defined tile.

1   40. The computer program product of claim 29, wherein each layer

2 comprises a window, and wherein the image comprises a display for a win-

3 dowing system.

1   41. The computer program product of claim 29, wherein a first one of the

2 layers in the set overlaps a second one of the layers in the set, and wherein each

3 layer comprises bounds defined by edges, and wherein at least one edge of the

4 first layer lies within the bounds of the second layer, and wherein the computer-

5 readable program code devices configured to cause a computer to define as a tile

6 an area of overlap comprises:

7   computer-readable program code devices configured to cause a computer

8   to subdivide the second layer along a line corresponding to an

9   extension of the at least one edge of the first layer that lies within

10   the bounds of the second layer.

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1   42.`The computer program product of claim 29, wherein:

2   the computer-readable program code devices configured to cause a com-

3   puter to select one of the layers comprise computer-readable

4   program code devices configured to cause a computer to select one

5   of the layers in the set of at least two layers, the selected layer

6   having a layer pixel corresponding to the image pixel, the layer

7   pixel having a color value and an alpha value; and

8   the computer-readable program code devices configured to cause a com-

9   puter to composite the color value of the layer pixel with the

10   accumulator color value are configured to cause a computer to use

11   the alpha value to composite the color value.

1   43. A system for combining at least two overlapping layers to render an

2   image, the image containing a plurality of image pixels, each overlapping layer

3   containing a plurality of layer pixels, each layer pixel corresponding to one of the

4   image pixels, the system comprising:

5   tile subdividing means, for defining a tile, the tile comprising a subset of

6   the image pixels delimited according to an area of overlap among a

7   set of at least two layers, so that a first portion of the image lies

8   within the tile and a second portion of the image lies outside the

9   tile;

10   accumulating means for initializing an accumulator color value for at least

11   one image pixel in the defined tile;

12   layer selecting means, for successively selecting each of at least a subset of

13   the layers in the set of at least two layers, each selected layer having

14   a layer pixel corresponding to the image pixel, the layer pixel

15   having a color value;

16   compositing means, coupled to the layer selecting means and to the

17   accumulating means, for, for each successively selected layer,

18   compositing the color value of the layer pixel with the accumulator

19   color value and storing the result in the accumulating means; and

20   output means, coupled to the accumulating means, for outputting the

21   accumulator color value;

22   wherein in combining the overlapping layers, the accumulating means,

23   the layer selecting means, and the compositing means process the

24   first portion of the image distinctly from the second portion of the

25   image.

1   44. The system of claim 43, wherein each layer pixel has an opacity value,

2   and wherein:

3   the accumulating means further initializes an accumulator opacity value;

4   the compositing means further composites the opacity value of the layer

5   pixel with the accumulator opacity value and stores the result in

6   the accumulating means; and

7   the subset of overlapping layers selected by the layer selecting means is

8   determined responsive to a comparison of the accumulator opacity

9   value with a full opacity value.

1   45. The system of claim 43, wherein the layer selecting means successively

2 selects layers by selecting a topmost remaining layer in the set of at least two

3 layers.

1   46. The system of claim 43, wherein the output means outputs the ac-

2 cumulator value to a frame buffer.

1   47. The system of claim 43, further comprising display means, coupled to

2 the output means, for displaying the image.

1   48. The system of claim 43, wherein each of the layer selecting means,

2 compositing means, accumulating means, and output means operates on each

3 image pixel in the defined tile.

1   49. The system of claim 43, wherein each of the layer selecting means,

2 compositing means, accumulating means, and output means operates on at least

3 two image pixels concurrently.

1   50. The system of claim 43, further comprising a second accumulating

2 means, coupled to the compositing means, for initializing a second accumulator

3 color value for a second image pixel in the defined tile, and wherein:

4   the layer selecting means, concurrently with successively selecting each of

5   at least a subset of the layers in the set of at least two layers having

6   a layer pixel corresponding to the first image pixel, selects one of

7   the layers in the set of at least two layers having a second layer

8   pixel corresponding to the second image pixel, the second layer

9   pixel having a color value;

10   the compositing means, concurrently with compositing the first color

11   value of the layer pixel with the accumulator color value,

12   composites the color value of the second layer pixel with the

13   second accumulator color value and stores the result in the second

14   accumulating means; and

15   the output means outputs the second accumulator color value.

1   51. The system of claim 43, wherein at least one of the layers in the set of

2   at least two layers is non-rectangular.

1   52. The system of claim 43, wherein at least one pixel of at least one of the

2   layers in the set of at least two layers is transparent, and wherein the

3   compositing means:

4   responsive to the layer pixel being transparent, retains the accumulator

5   color value; and

6   responsive to the layer pixel not being transparent, composites the color

7   value of the layer pixel with the accumulator color value.

1   53. The system of claim 43, wherein:

2   the tile subdividing means defines as a second tile a second area of

3   overlap between a second set of at least two layers, the tile

4   comprising a second subset of the image pixels;

5   the accumulating means initializes a second accumulator color value for

6   at least one image pixel in the second defined tile;

7   the layer selecting means successively selects each of at least a subset of

8   the layers in the second set of at least two layers, each selected

9   layer having a layer pixel corresponding to the image pixel, the

10   layer pixel having a color value;

11   the compositing means, for each successively selected layer, composites

12   the color value of the layer pixel with the second accumulator

13   color value and stores the result in the accumulator; and

14   the output means outputs the second accumulator color value.

1   54. The system of claim 43, wherein each layer comprises a window, and

2   wherein the image comprises a display for a windowing system.

1   55. The system of claim 43, wherein a first one of the layers in the set

2   overlaps a second one of the layers in the set, and wherein each layer comprises

3   bounds defined by edges, and wherein at least one edge of the first layer lies

4   within the bounds of the second layer, and wherein the tile subdividing means

5   comprises:

6   means for subdividing the second layer along a line corresponding to an

7   extension of the at least one edge of the first layer that lies within

8   the bounds of the second layer

1   56. The system of claim 43, wherein:

2   the layer selecting means successively selects each of at least a subset of

3   the layers in the set of at least two layers, each selected layer having

4   a layer pixel corresponding to the image pixel, the layer pixel

5   having a color value and an alpha value; and

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6   the compositing means composites the color value of the layer pixel with

7   the accumulator color value, using the alpha value.

1   57. In an image containing a plurality of layers, wherein a first one of the

2   layers overlaps a second one of the layers, and wherein each layer comprises

3   bounds defined by edges, and wherein at least one edge of the first layer lies

4   within the bounds of the second layer layers, a method of subdividing tiles,

5   comprising:

6   subdividing the second layer along a straight line corresponding to an

7   extension of the at least one edge of the first layer that lies within

8   the bounds of the second layer, to obtain two tile subdivisions; and

9   storing, in a tile list, a representation of at least a subset of the obtained tile

10   subdivisions.

1   58. The method of claim 57, further comprising:

2   repeating the subdividing step using at least one of the obtained tile

3   subdivisions.

1   59. The method of claim 57, further comprising:

2   joining at least two adjacent tile subdivisions in the tile list.

1   60. The method of claim 57, further comprising:

2   responsive to at least two adjacent tile subdivisions including portions of

3   the same set of identical layers as one another, joining the at least

4   two adjacent tile subdivisions in the tile list.

1   61. In a device containing an image having a plurality of layers, wherein a

2   first one of the layers overlaps a second one of the layers, and wherein each layer

3   comprises bounds defined by edges, and wherein at least one edge of the first

4   layer lies within the bounds of the second layer layers, a system for subdividing

5   tiles, comprising:

6   a tile subdivider, for subdividing the second layer along a straight line

7   corresponding to an extension of the at least one edge of the first

8   layer that lies within the bounds of the second layer, to obtain two

9   tile subdivisions; and

10   a tile list, coupled to the tile subdivider, for storing a representation of at

11   least a subset of the obtained tile subdivisions.

1   62. The system of claim 61, wherein:

2   the tile subdivider repeats the subdividing using at least one of the

3   obtained tile subdivisions.

1   63. The system of claim 61, further comprising:

2   a tile joiner, coupled to the tile list, for joining at least two adjacent tile

3   subdivisions in the tile list.

1   64. The system of claim 61, further comprising:

2   a tile joiner, coupled to the tile list, for, responsive to at least two adjacent

3   tile subdivisions including portions of the same set of identical

4   layers as one another, joining the at least two adjacent tile

5   subdivisions in the tile list.

1   65. A computer program product comprising a computer-usable medium

2   having computer-readable code embodied therein for, in an image containing a

3   plurality of layers, wherein a first one of the layers overlaps a second one of the

4   layers, and wherein each layer comprises bounds defined by edges, and wherein

5   at least one edge of the first layer lies within the bounds of the second layer

6   layers, subdividing tiles, comprising:

7   computer-readable program code devices configured to cause a computer

8   to subdivide the second layer along a straight line corresponding to

9   an extension of the at least one edge of the first layer that lies

10   within the bounds of the second layer, to obtain two tile

11   subdivisions; and

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12   computer-readable program code devices configured to cause a computer

13   to store, in a tile list, a representation of at least a subset of the

14   obtained tile subdivisions.

1   66. The computer program product of claim 65, further comprising:

2   computer-readable program code devices configured to cause a computer

3   to repeat the subdividing using at least one of the obtained tile

4   subdivisions.

1   67. The computer program product of claim 65, further comprising:

2   computer-readable program code devices configured to cause a computer

3   to join at least two adjacent tile subdivisions in the tile list.

1   68. The computer program product of claim 65, further comprising:

2   computer-readable program code devices configured to cause a computer

3   to, responsive to at least two adjacent tile subdivisions including

4   portions of the same set of identical layers as one another, join the

5   at least two adjacent tile subdivisions in the tile list.

1   69. In a device containing an image having a plurality of layers, wherein a

2   first one of the layers overlaps a second one of the layers, and wherein each layer

3   comprises bounds defined by edges, and wherein at least one edge of the first

4   layer lies within the bounds of the second layer layers, a system for subdividing

5   tiles, comprising:

6   tile subdividing means, for subdividing the second layer along a straight

7   line corresponding to an extension of the at least one edge of the

8   first layer that lies within the bounds of the second layer, to obtain

9   two tile subdivisions; and

10   tile list storage means, coupled to the tile subdividing means, for storing a

11   representation of at least a subset of the obtained tile subdivisions.

1   70. The system of claim 69, wherein:

2   the tile subdividing means repeats the subdividing using at least one of

3   the obtained tile subdivisions.

1   71. The system of claim 69, further comprising:

2   tile joining means, coupled to the tile list storage means, for joining at least

3   two adjacent tile subdivisions in the tile list.

1   72. The system of claim 69, further comprising:

2   tile joining means, coupled to the tile list storage means, for, responsive

3   to at least two adjacent tile subdivisions including portions of the

4   same set of identical layers as one another, joining the at least two

5   adjacent tile subdivisions in the tile list.

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